



**US Army Corps
of Engineers**
Waterways Experiment
Station

Preliminary Data Summary December 1999 Field Research Facility

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The logo for Waterways Experiment Station (WES), consisting of the letters "WES" in a bold, italicized font, with each letter composed of horizontal lines.

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1 Introduction

The U.S. Army Corps of Engineers Waterways Experiment Station, Coastal and Hydraulics Laboratory (CHL), Field Research Facility (FRF) is located on the Outer Banks of North Carolina, near the village of Duck (Figure 1).

The FRF research program provides a means for obtaining high-quality field data, particularly during storms, in support of the U.S. Army Corps of Engineers' coastal engineering research missions. Central to the FRF is the research pier, a reinforced concrete structure which extends from behind the duneline to about the 6-m water depth contour at a height of 7.75 m above the NGVD (1929 National Geodetic Vertical Datum).

One of the responsibilities of the FRF research program is the collection, analysis and dissemination of data on local bathymetric, oceanographic, and meteorological conditions. This is a preliminary which provides basic data soon after collection. Since they are preliminary further quality control may be applied to the data and made available via the internet at <http://www.frf.usace.army.mil>. Questions and/or comments concerning the data may be directed to Mr. Clifford F. Baron at (919)261-6840 ext.222 (*baronc@wes.army.mil*).

Chapter 2 presents the meteorological data; Chapters 3 through 6 present oceanographic data; Chapter 7 presents nearshore profiles and bathymetry; and Chapter 8 documents special events that occurred at the FRF during the month.

Table 1 is a list of instruments used and their operational status during the month. Figure 2 shows weather and ocean conditions for the month. Table 2 and Figure 3 identifies the location of the instruments. The water depths at the wave gauges and current meters vary and may be determined from information contained in Figure 9. Other installation information is contained in Table 2.

Times given in the report are referenced to eastern standard time (EST).



Figure 1. FRF Location Map

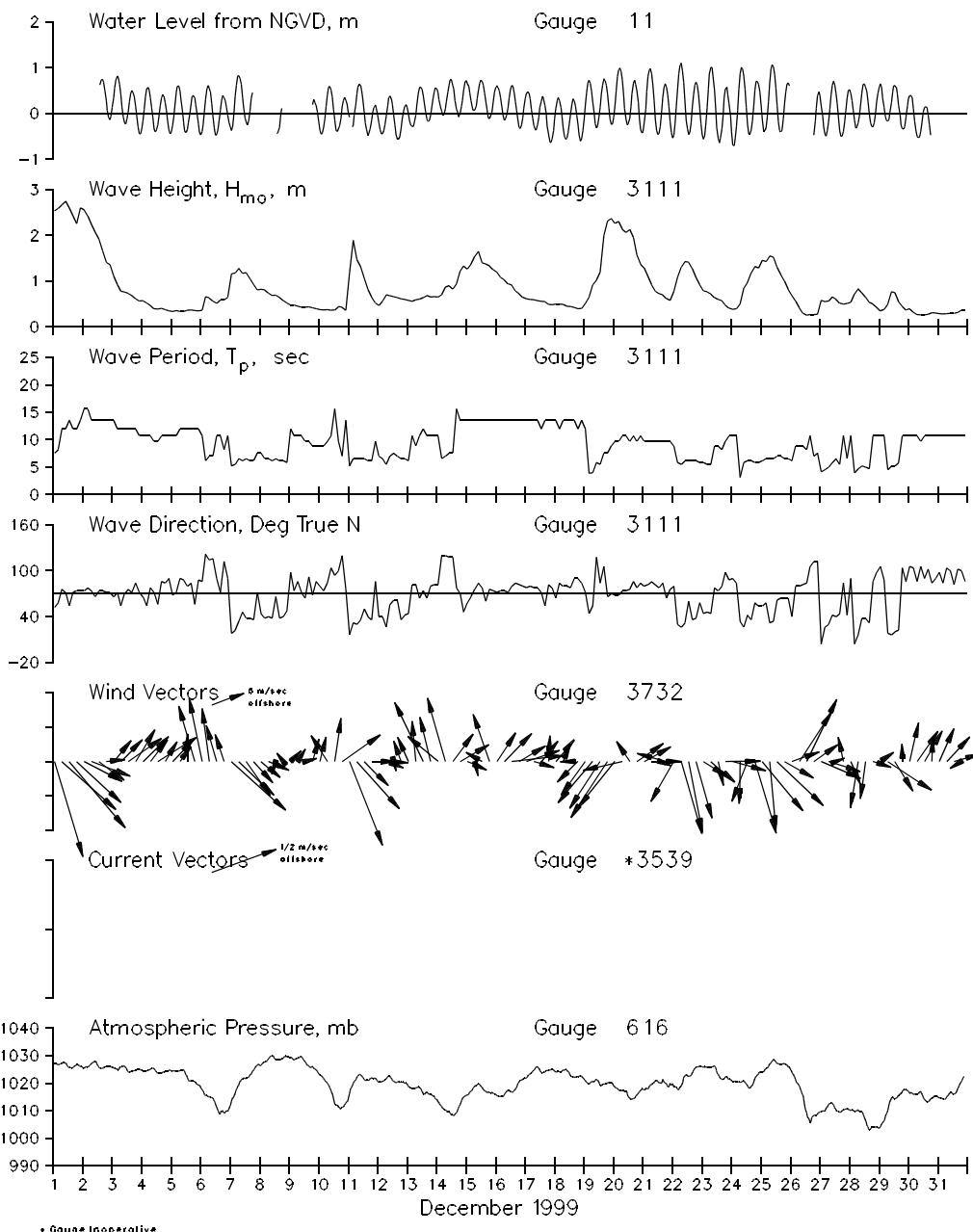


Figure 2. Month at a Glance

Table 1
Instrument Status/Data Availability

		December 1999																																
		Day of the month																																
Gauge ID	Description/Remarks	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1		
616	Atmospheric Pressure	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
604	Precipitation	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*		
624	Air Temperature	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*		
3732	Anemometer	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*		
641	Pressure Gauge on FRF pier	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*		
625	Baylor staff on FRF pier	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*		
3111	8 Meter Array 309 m north of FRF	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
111	Pressure Gauge center of 8 Meter Array	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
630	Waverider buoy 4.0 km offshore	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
		Data Collected	*	/	-	-	-	/	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*		
3539	Current meter 343 m north of FRF pier (1.6 km offshore)	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
		Data Collected	Data available at a later date.																															
11	NOAA tide gauge at end of pier	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
		Data Collected	/	/	*	*	*	*	/	-	/	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
Visual Observations (daily oceanographic and meteorological observations)		Daily observation	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
Gauge Status		*	= Operational	/	= Partial	-	= Non-Operational																											
Data Collected		*	= All	/	= Partial	-	= None																											
Visual Observations		*	= Complete	/	= Partial	-	= None																											

Table 2 Gauge Locations

Gauge ID	Description	Latitude Degrees N	Longitude Degrees W	FRF Coordinates Crossshore m	Longshore m	Gauge Depth NGVD, m	Water Depth NGVD, m
616	Atmospheric Pressure	36 10' 57.03"	75 45' 5.50"	11.60	569.00	-----	-----
3932	Anemometer	36 11' 1.23"	75 44' 43.07"	585.20	517.30	19.50	-----
641	Pressure Gauge	36 10' 57.71"	75 44' 56.23"	239.11	516.64	-1.64	-1.96
625	Baylor Staff	36 11' 1.04"	75 44' 43.72"	568.00	516.64	Surface	-8.36
3111	8 Meter Array North	36 11' 19.14"	75 44' 36.41"	915.23	990.16	-7.50	-7.90
	8 Meter Array South	36 11' 11.28"	75 44' 33.28"	914.20	735.37	-7.42	-7.90
	8 Meter Array East	36 11' 13.70"	75 44' 32.56"	954.51	800.58	-7.62	-8.13
	8 Meter Array West	36 11' 12.48"	75 44' 37.11"	834.66	800.37	-6.98	-7.44
111	Pressure Gauge in center of 8 M Array	36 11' 14.06"	75 44' 34.39"	914.43	825.52	-7.76	-8.08
630	Waverider Buoy	36 10' 5.10"	75 41' 59.30"	3934.96	-2400.81	Surface	-17.00
3539	Current Meter	36 11' 23.57"	75 44' 9.12"	1605.80	907.60	-11.60	-11.70
11	NOAA Tide Gauge	36 11' 1.25"	75 44' 42.60"	596.49	514.20	Surface	-7.62

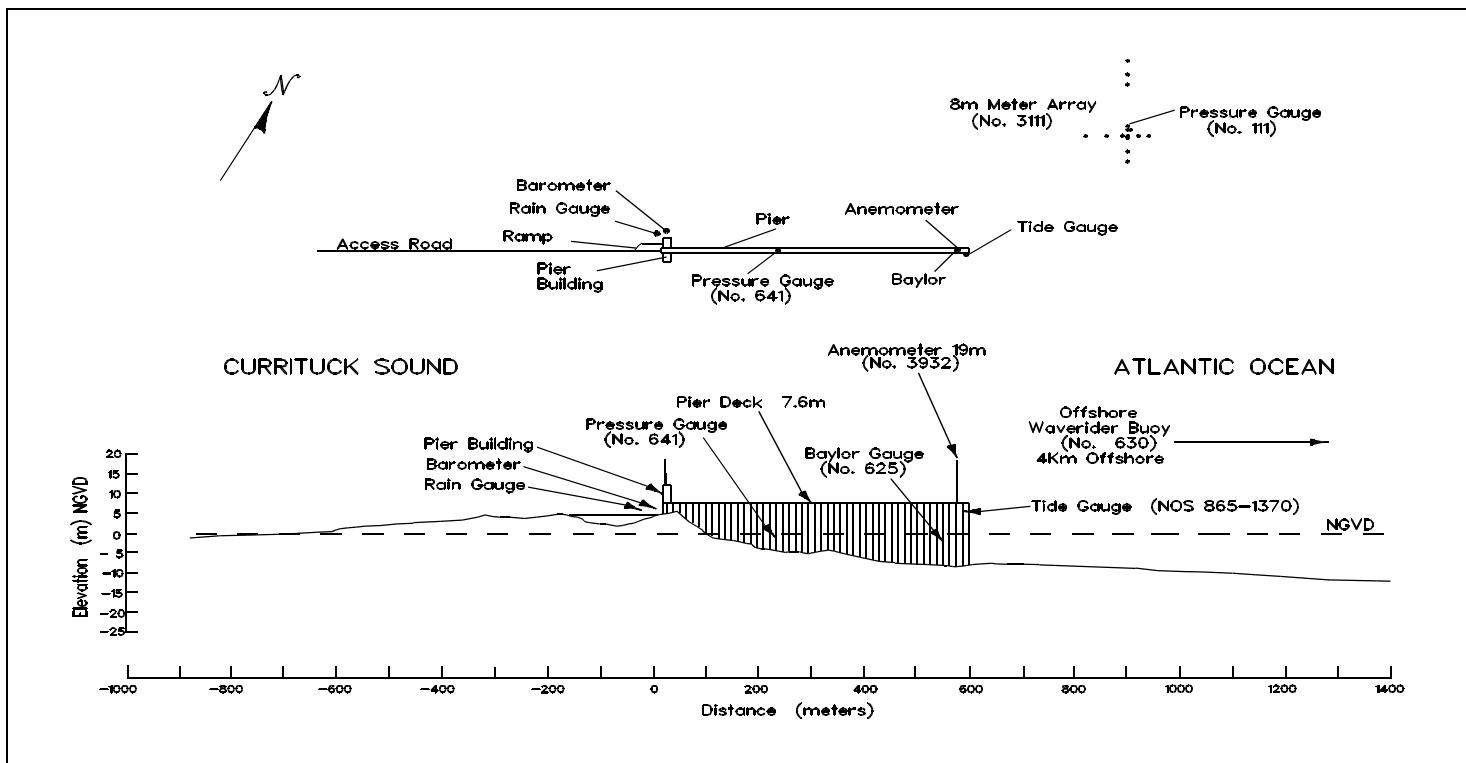


Figure 3. Instrument Locations, Elevations From NGVD

2 Meteorological Data

A variety of instruments have been installed at the FRF (Figure 3) to monitor the meteorological conditions. The data presented in Table 3 are collected and stored using a Digital Equipment Corporation VAXstation 4000. For each instrument identified in Table 1, a log is maintained and the records are stored for future reference.

Winds were measured at the end of the pier at an elevation of 19 m using a WeatherMeasure Skyvane anemometer. Monthly resultant wind speeds and directions (Figure 4) are determined by vector averaging the data. Wind directions (Table 3) indicate where the wind is coming from. Temperature and atmospheric pressure means (Table 3) are the average of the values presented for the month. Total precipitation is the sum for the month.

The following may be useful for converting the data in Table 3 to other frequently used units of measurement:

1. Millimeters (mm) to inches (in.) -
 $mm \times .03937 = in.$
2. Millibars (mb) to inches of mercury (in. Hg) -
 $mb \times 0.02953 = in. Hg$
3. Degrees Celsius (C) to degrees Fahrenheit (F) -
 $(C \times 9/5) + 32 = F$
4. Meters per second (m/s) to knots (kn) -
 $m/s \times 1.943 = kn$

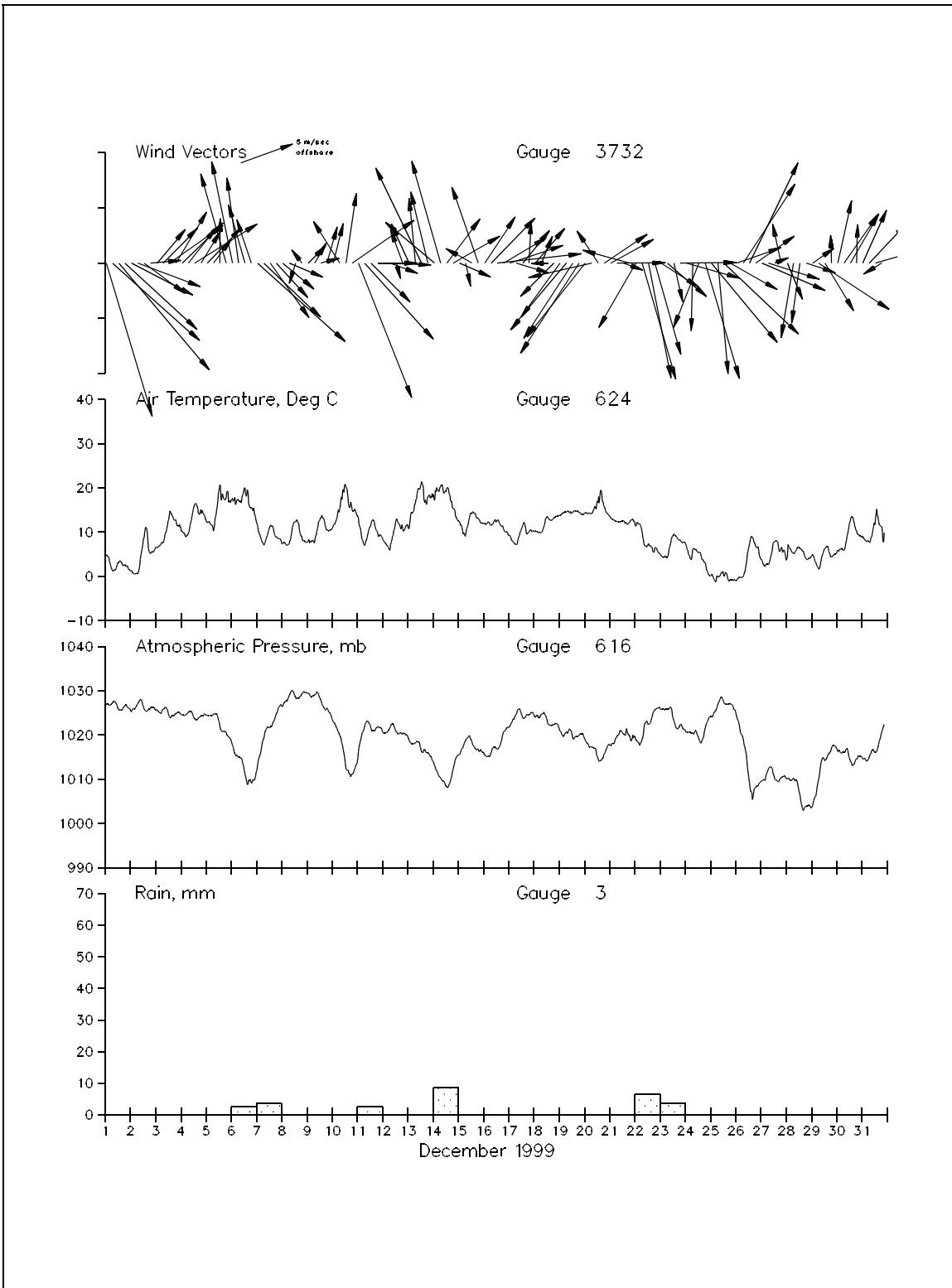


Figure 4. Meteorological Monthly Summary

Table 3
Meteorological Data

Dec 1999						
Day	Hour	Wind Speed m/sec	Wind Direction deg TN	Temperature deg C	Atm Pressure mb	Precipitation mm
1	100	14	343	4.9	1027.1	0
	700	11	311	1.4	1027.5	0
	1300	13	319	3.2	1025.7	0
	1900	9	312	2.7	1026.8	0
2	100	6	297	1.4	1025.4	0
	700	6	290	0.6	1027.2	0
	1300	5	306	8.9	1025.9	0
	1900	3	265	5.2	1026.3	0
3	100	4	220	6.4	1025.7	0
	700	4	224	7.5	1025.9	0
	1300	6	234	14.1	1024.3	0
	1900	5	211	12.8	1024.8	0
4	100	5	225	10.3	1024.6	0
	700	4	218	9.6	1025.3	0
	1300	7	237	16.3	1023.7	0
	1900	3	211	15.1	1024.5	0
5	100	4	223	12.2	1024.5	0
	700	3	216	10.3	1024.8	0
	1300	4	180	20.6	1022.2	0
	1900	8	164	17.8	1020.7	0
6	100	9	168	17.5	1017.7	0
	700	8	172	17.1	1015.0	3
	1300	5	163	20.1	1011.3	0
	1900	4	161	15.6	1009.2	0
7	100	11	311	11.3	1013.4	0
	700	7	313	7.1	1019.5	4
	1300	6	324	11.5	1021.9	0
	1900	4	317	9.0	1025.0	0
8	100	4	310	7.5	1026.7	0
	700	3	292	7.4	1029.0	0
	1300	2	17	12.4	1028.5	0
	1900	1	142	9.2	1029.3	0
9	100	2	225	8.0	1029.4	0
	700	2	211	7.6	1029.2	0
	1300	2	255	13.3	1027.9	0
	1900	3	196	10.6	1026.2	0
10	100	4	194	11.5	1023.0	0
	700	4	147	15.3	1020.1	0
	1300	6	188	20.1	1012.5	0
	1900	7	235	15.1	1011.2	0

Table 3
Meteorological Data (continued)

Dec 1999						
Day	Hour	Wind Speed m/sec	Wind Direction deg TN	Temperature deg C	Atm Pressure mb	Precipitation mm
11	100	13	338	13.1	1016.3	0
	700	9	318	7.0	1022.3	3
	1300	5	315	12.0	1021.5	0
	1900	4	270	9.9	1021.9	0
	12	100	4	272	8.1	1020.5
12	700	3	290	6.0	1021.7	0
	1300	1	345	13.0	1020.8	0
	1900	3	159	10.7	1020.4	0
	13	100	4	155	10.8	1018.9
13	700	6	174	16.6	1018.3	0
	1300	10	154	21.5	1016.2	0
	1900	7	166	18.1	1016.1	0
	14	100	6	129	17.3	1013.2
14	700	10	164	20.3	1010.4	8
	1300	5	216	19.9	1008.5	0
	1900	5	239	15.5	1012.3	0
	15	100	3	294	12.4	1015.7
15	700	2	348	9.2	1018.7	0
	1300	3	119	14.3	1018.5	0
	1900	7	160	13.1	1016.8	0
	16	100	5	213	11.9	1015.5
16	700	6	224	11.5	1016.0	0
	1300	8	263	12.7	1016.9	0
	1900	4	239	10.7	1020.7	0
	17	100	5	251	9.3	1022.0
17	700	3	286	7.3	1024.8	0
	1300	4	219	11.4	1024.0	0
	1900	4	183	10.1	1024.7	0
	18	100	4	220	10.2	1024.0
18	700	3	202	9.9	1024.8	0
	1300	2	88	13.5	1022.6	0
	1900	4	44	13.4	1022.5	0
	19	100	6	35	13.9	1021.0
19	700	8	39	14.6	1020.8	0
	1300	8	33	14.5	1019.1	0
	1900	10	32	14.4	1020.1	0
	20	100	9	38	14.4	1018.8
20	700	6	76	14.3	1017.4	0
	1300	3	146	16.7	1014.7	0
	1900	5	235	15.8	1015.9	0

Table 3
Meteorological Data (concluded)

Dec 1999						
Day	Hour	Wind Speed m/sec	Wind Direction deg TN	Temperature deg C	Atm Pressure mb	Precipitation mm
21	100	4	240	13.3	1017.7	0
	700	4	269	12.5	1019.8	0
	1300	2	290	12.5	1020.4	0
	1900	4	105	12.3	1019.9	0
22	100	7	29	11.4	1018.8	0
	700	11	343	10.0	1019.2	6
	1300	11	349	7.4	1022.4	0
	1900	9	344	6.4	1025.8	0
23	100	4	302	4.7	1025.8	0
	700	5	310	4.4	1026.0	3
	1300	4	347	9.6	1023.2	0
	1900	5	269	8.3	1022.4	0
24	100	5	285	6.8	1020.6	0
	700	6	1	6.2	1020.5	0
	1300	6	21	5.5	1019.1	0
	1900	11	343	3.0	1021.6	0
25	100	9	320	0.5	1024.2	0
	700	10	354	-0.1	1027.1	0
	1300	9	313	0.0	1027.3	0
	1900	5	299	-0.9	1027.2	0
26	100	4	250	-0.7	1024.0	0
	700	9	213	-0.1	1019.1	0
	1300	10	205	7.4	1009.2	0
	1900	4	234	6.8	1008.3	0
27	100	6	293	3.7	1009.7	0
	700	5	287	2.6	1012.4	0
	1300	1	248	7.9	1010.2	0
	1900	4	167	6.5	1010.4	0
28	100	4	337	4.4	1010.1	0
	700	7	9	5.2	1010.3	0
	1300	5	7	6.5	1006.5	0
	1900	3	288	4.0	1004.0	0
29	100	2	235	5.0	1004.1	0
	700	8	303	1.6	1010.1	0
	1300	5	328	6.4	1014.4	0
	1900	3	178	4.4	1017.2	0
30	100	6	192	6.0	1016.3	0
	700	5	214	5.9	1016.2	0
	1300	5	210	12.5	1014.3	0
	1900	3	181	10.4	1014.6	0
31	100	5	204	8.9	1014.8	0
	700	5	223	7.7	1015.1	0
	1300	4	254	12.9	1016.1	0
	1900	2	58	11.2	1020.8	0
		Resultant		Mean	Mean	Total
		2	266	9.9	1019.7	27

3 Wave Data

Wave data are collected from three different sets of instruments, as shown in Table 1 and Figure 3. The first is an array of fifteen pressure gauges, collectively referred to as gauge 3111 (gauge 111 being one of them). Directional information is computed from these gauges using an iterative maximum likelihood estimator. The second is a Baylor staff gauge (625) and a pressure gauge (641), both attached to the pier. The third is a Waverider buoy (630). The data are collected, analyzed, and stored on optical disc using a Digital Equipment Corporation VAXstation 4000. Data is sampled at 2 Hertz, with five contiguous 34 minute records, for a total collection period of nearly 2 hours and 51 minutes. This report reflects the data collection periods of 0100, 0700, 1300, and 1900 EST. The results are based only on the first 34 minute record. The exception is the 8 Meter Array (3111) which condenses the first four records into one statistical value.

Wave height H_{mo} is an energy-based statistic equal to four times the standard deviation of the sea surface elevations. Wave height reported from the pressure gauge has been compensated for hydrodynamic attenuation using linear wave theory. Wave period is identified from the computation of a variance (energy) spectrum with 60 degrees of freedom calculated from a 34-min record. Peak wave period T_p is defined as the period associated with the maximum energy in the spectrum.

Table 4 presents the wave heights and periods for each wave record obtained at 6 hr intervals during the month. The monthly means and standard deviations from the means shown in Table 4 are average values computed from this data. Figure 5 is a time history of all H_{mo} and T_p values obtained for all gauges.

Differences in wave periods between wave gauges (Table 4 and Figure 5) may be the result of wave breaking, wave reformation, the presence of multiple wave trains containing nearly equal energy, and statistical variations in spectral estimations.

Table 4
Wave Data

Dec 1999											
Day	Hour	641 Pressure Gauge		625 Baylor Gauge		3111 8 Meter Array			630 Waverider		
		Hmo,m	Tp,sec	Hmo,m	Tp,sec	Hmo,m	Tp,sec	Dir,TN	Hmo,m	Tp,sec	
1	0100	1.41	7.8	2.29	7.8	2.54	7.6	52	2.55	7.2	
	0700	1.09	10.7	2.36	10.7	2.67	12.0	76	2.67	10.6	
	1300	1.54	12.9	2.57	12.2	2.60	13.6	54	2.90	12.6	
	1900	1.17	13.5	2.10	12.9	2.26	12.0	74	2.50	12.6	
2	0100	1.57	14.3	2.41	13.5	2.56	15.7	74	2.76	15.4	
	0700	1.30	14.3	2.06	14.3	2.23	13.6	74	2.41	13.4	
	1300	1.24	14.3	1.81	13.5	1.92	13.6	74			
	1900	0.90	14.3	1.31	14.3	1.41	13.6	72			
3	0100	0.60	13.5	1.07	12.9	1.12	13.6	66			
	0700	0.34	13.5	0.73	11.7	0.78	12.0	54			
	1300	0.26	11.7	0.66	11.7	0.73	12.0	76			
	1900	0.24	11.7	0.58	11.2	0.62	12.0	84			
4	0100	0.20	10.7	0.54	10.7	0.57	10.8	66			
	0700	0.20	10.7	0.41	10.7	0.47	10.8	78			
	1300	0.15	10.3	0.37	10.7	0.39	9.8	56			
	1900	0.19	10.7	0.35	10.3	0.38	10.8	84			inoperative
5	0100	0.15	12.9	0.34	10.3	0.34	10.8	68			
	0700	0.17	12.2	0.31	10.3	0.33	12.0	90			
	1300	0.13	12.2	0.32	12.2	0.36	12.0	80			
	1900	0.20	11.2	0.34	12.2	0.36	12.0	56			
6	0100	0.22	11.7	0.40	11.7	0.36	10.8	86			
	0700	0.38	6.6	0.57	6.1	0.63	7.1	114			
	1300	0.23	7.2	0.50	7.2	0.51	10.8	90			
	1900	0.35	8.1	0.57	8.1	0.59	8.2	112			
7	0100	0.67	4.6	0.98	4.8	1.16	5.3	18			
	0700	0.99	6.1	1.20	6.5	1.28	6.6	34	1.46	6.7	
	1300	0.74	6.5	1.19	7.2	1.18	6.6	38	1.32	7.2	
	1900	0.64	6.5	0.88	6.6	0.93	6.2	36	1.14	7.2	
8	0100	0.52	5.2	0.83	7.6	0.82	7.6	44	1.05	7.7	
	0700	0.52	6.3	0.69	6.6	0.74	6.6	40	0.96	6.7	
	1300	0.37	6.5	0.69	6.6	0.69	6.6	66	0.88	7.2	
	1900	0.37	5.9	0.57	5.7	0.58	6.2	40	0.75	5.9	
9	0100	0.20	15.1	0.46	11.7	0.47	12.0	98	0.56	11.8	
	0700	0.27	11.2	0.42	11.2	0.45	10.8	86	0.51	10.6	
	1300	0.16	10.7	0.40	9.9	0.43	9.8	64	0.46	10.1	
	1900	0.21	8.9	0.41	9.2	0.41	8.9	68	0.50	9.1	
10	0100	0.16	16.0	0.38	9.5	0.38	8.9	80	0.41	10.1	
	0700	0.21	15.1	0.34	9.9	0.38	9.8	84	0.40	10.1	
	1300	0.23	14.3	0.45	14.3	0.37	15.7	94	0.57	15.4	
	1900	0.26	14.3	0.41	14.3	0.43	7.1	120	0.68	6.3	

Table 4
Wave Data (continued)

Dec 1999											
Day	Hour	641 Pressure Gauge		625 Baylor Gauge		3111 8 Meter Array			630 Waverider		
		Hmo,m	Tp,sec	Hmo,m	Tp,sec	Hmo,m	Tp,sec	Dir,TN	Hmo,m	Tp,sec	
11	0100	0.35	3.4	0.57	2.9	1.17	5.3	16	0.53	13.4	
	0700	1.23	6.3	1.39	6.6	1.47	6.6	30	2.10	7.2	
	1300	0.84	6.1	1.13	8.6	1.06	6.6	50	1.48	6.3	
	1900	0.47	4.9	0.68	6.0	0.64	6.2	36	0.89	5.3	
12	0100	0.29	4.5	0.50	7.2	0.47	7.1	40	0.69	7.2	
	0700	0.53	4.9	0.72	5.9	0.70	5.6	26	0.85	6.3	
	1300	0.45	4.8	0.76	7.6	0.66	7.6	62	0.87	6.7	
	1900	0.40	4.9	0.66	7.0	0.61	6.6	36	0.82	6.7	
13	0100	0.28	10.3	0.61	5.9	0.58	6.2	44	0.70	5.9	
	0700	0.24	11.7	0.54	9.5	0.59	8.9	82	0.65	10.1	
	1300	0.31	11.7	0.61	11.2	0.64	12.0	74	0.67	11.2	
	1900	0.27	11.7	0.61	11.2	0.65	10.8	80	0.80	11.2	
14	0100	0.30	11.2	0.58	11.2	0.65	10.8	82	0.75	11.8	
	0700	0.46	7.0	0.76	6.8	0.87	7.1	120	1.09	7.2	
	1300	0.47	7.8	0.72	11.7	0.83	7.6	118	1.04	6.7	
	1900	0.61	14.3	1.19	14.3	1.23	13.6	70	1.28	14.3	
15	0100	0.79	14.3	1.20	13.5	1.27	13.6	58	1.43	13.4	
	0700	0.80	15.1	1.37	14.3	1.54	13.6	76	1.52	13.4	
	1300	0.81	15.1	1.36	14.3	1.40	13.6	78	1.49	14.3	
	1900	0.73	14.3	1.31	14.3	1.33	13.6	76	1.37	14.3	
16	0100	0.56	14.3	1.24	14.3	1.20	13.6	72	1.18	12.6	
	0700	0.40	14.3	1.03	14.3	1.03	13.6	74	1.06	15.4	
	1300	0.42	14.3	0.85	13.5	0.91	13.6	80	1.00	14.3	
	1900	0.28	13.5	0.78	13.5	0.72	13.6	82	0.87	14.3	
17	0100	0.28	13.5	0.58	12.9	0.62	13.6	78	0.68	13.4	
	0700	0.22	13.5	0.53	12.9	0.59	13.6	78	0.59	11.8	
	1300	0.22	12.9	0.52	12.9	0.56	12.0	72	0.56	13.4	
	1900	0.19	12.9	0.51	12.9	0.49	13.6	82	0.60	13.4	
18	0100	0.20	13.5	0.42	12.9	0.50	13.6	64	0.50	13.4	
	0700	0.18	12.9	0.47	12.2	0.49	13.6	80	0.44	12.6	
	1300	0.19	14.3	0.41	14.3	0.44	13.6	78	0.43	13.4	
	1900	0.17	12.2	0.42	12.2	0.39	12.0	90	0.44	13.4	
19	0100	0.31	12.9	0.57	12.9	0.51	12.0	72	0.60	13.4	
	0700	0.50	3.9	0.83	4.0	0.92	4.1	54	0.96	4.2	
	1300	0.59	4.4	1.11	5.6	1.20	5.6	84	1.34	5.9	
	1900	1.08	7.6	2.25	7.4	2.31	7.6	66	2.30	8.4	
20	0100	1.15	9.2	2.32	9.5	2.26	9.8	68	2.74	9.1	
	0700	1.27	8.9	2.12	10.7	2.13	10.8	74	2.27	11.2	
	1300	0.97	10.3	2.11	10.3	2.13	9.8	76	2.27	10.1	
	1900	0.86	10.3	1.63	10.3	1.57	9.8	78	1.70	10.1	

Table 4
Wave Data (concluded)

Dec 1999										
Day	Hour	641		625		3111			630	
		Pressure Hmo,m	Gauge Tp,sec	Baylor Hmo,m	Gauge Tp,sec	8 Hmo,m	Meter Tp,sec	Array Dir,TN	Waverider Hmo,m	Tp,sec
21	0100	0.60	8.3	1.24	9.2	1.28	9.8	80	1.44	10.1
	0700	0.47	10.7	0.93	10.3	0.92	9.8	86	1.12	10.1
	1300	0.34	9.5	0.68	9.2	0.73	9.8	78	0.78	10.1
	1900	0.33	9.5	0.62	9.5	0.62	9.8	64	0.72	10.6
	0100	0.40	3.0	0.71	9.5	0.77	8.9	80	0.78	9.1
22	0700	0.90	5.9	1.14	5.7	1.30	5.6	26	1.29	5.6
	1300	0.69	6.3	1.45	6.3	1.42	6.2	60	1.70	5.9
	1900	0.87	6.0	1.10	6.5	1.08	6.2	38	1.33	6.3
	0100	0.46	5.9	0.82	5.9	0.79	5.9	44	0.93	5.9
23	0700	0.54	5.6	0.73	5.9	0.72	5.6	44	0.88	5.6
	1300	0.27	5.4	0.58	8.9	0.60	8.9	74	0.65	7.7
	1900	0.28	4.7	0.47	8.3	0.48	9.8	98	0.60	10.6
	0100	0.10	10.3	0.35	9.9	0.38	10.8	90	0.42	9.1
24	0700	0.36	2.9	0.54	9.9	0.50	3.2	34	0.52	9.1
	1300	0.64	6.1	1.02	6.0	0.98	6.2	42	1.10	6.3
	1900	1.02	5.3	1.18	5.7	1.32	5.9	58	1.44	5.6
	0100	0.80	6.0	1.41	6.1	1.46	6.2	54	1.65	6.7
25	0700	1.22	6.5	1.46	6.5	1.54	6.6	32	1.77	6.7
	1300	0.92	6.8	1.28	7.0	1.30	7.1	62	1.55	6.7
	1900	0.78	6.3	0.98	7.0	1.00	6.6	64	1.24	6.3
	0100	0.45	6.3	0.70	6.5	0.68	6.2	40	0.86	6.3
26	0700	0.20	9.5	0.42	8.3	0.42	8.9	80	0.66	7.2
	1300	0.15	10.7	0.25	8.6	0.26	8.2	84	0.65	2.6
	1900	0.14	10.7	0.25	9.9	0.26	7.1	112	0.34	10.6
	0100	0.43	3.9	0.57	3.8	0.58	4.2	4	0.72	3.8
27	0700	0.42	5.1	0.57	5.4	0.57	5.0	30	0.65	6.3
	1300	0.48	5.5	0.63	7.6	0.60	6.6	40	0.84	7.7
	1900	0.26	5.0	0.50	6.5	0.50	10.8	84	0.65	6.3
	0100	0.34	6.5	0.52	10.7	0.54	10.8	90	0.61	10.6
28	0700	0.66	4.6	0.92	4.5	0.83	4.8	16	1.04	4.6
	1300	0.59	5.2	0.74	5.3	0.66	5.0	38	0.84	5.1
	1900	0.32	4.6	0.54	10.3	0.50	10.8	86	0.64	10.1
	0100	0.23	10.3	0.36	10.7	0.35	10.8	106	0.42	10.6
29	0700	0.34	4.5	0.46	4.8	0.50	4.6	18	0.81	3.6
	1300	0.69	5.5	0.72	5.6	0.75	5.3	20	1.11	5.9
	1900	0.32	5.5	0.44	5.6	0.45	10.8	104	0.57	5.6
	0100	0.28	3.5	0.41	10.7	0.39	10.8	106	0.59	10.6
30	0700	0.14	9.9	0.28	10.3	0.27	10.8	86	0.44	10.6
	1300	0.16	10.7	0.25	10.3	0.26	10.8	90	0.38	10.1
	1900	0.16	9.5	0.31	9.5	0.31	10.8	84	0.40	11.2
	0100	0.17	10.7	0.26	10.7	0.29	10.8	98	0.43	11.2
31	0700	0.17	11.2	0.30	10.7	0.29	10.8	104	0.40	10.6
	1300	0.16	10.3	0.26	10.7	0.30	10.8	82	0.34	11.2
	1900	0.20	11.2	0.36	10.3	0.37	10.8	100	0.40	10.5
	Mean	0.49	9.3	0.83	9.5	0.86	9.5	68	1.03	9.3
	Std dev	0.34	3.6	0.54	2.9	0.57	3.0	24	0.62	3.1

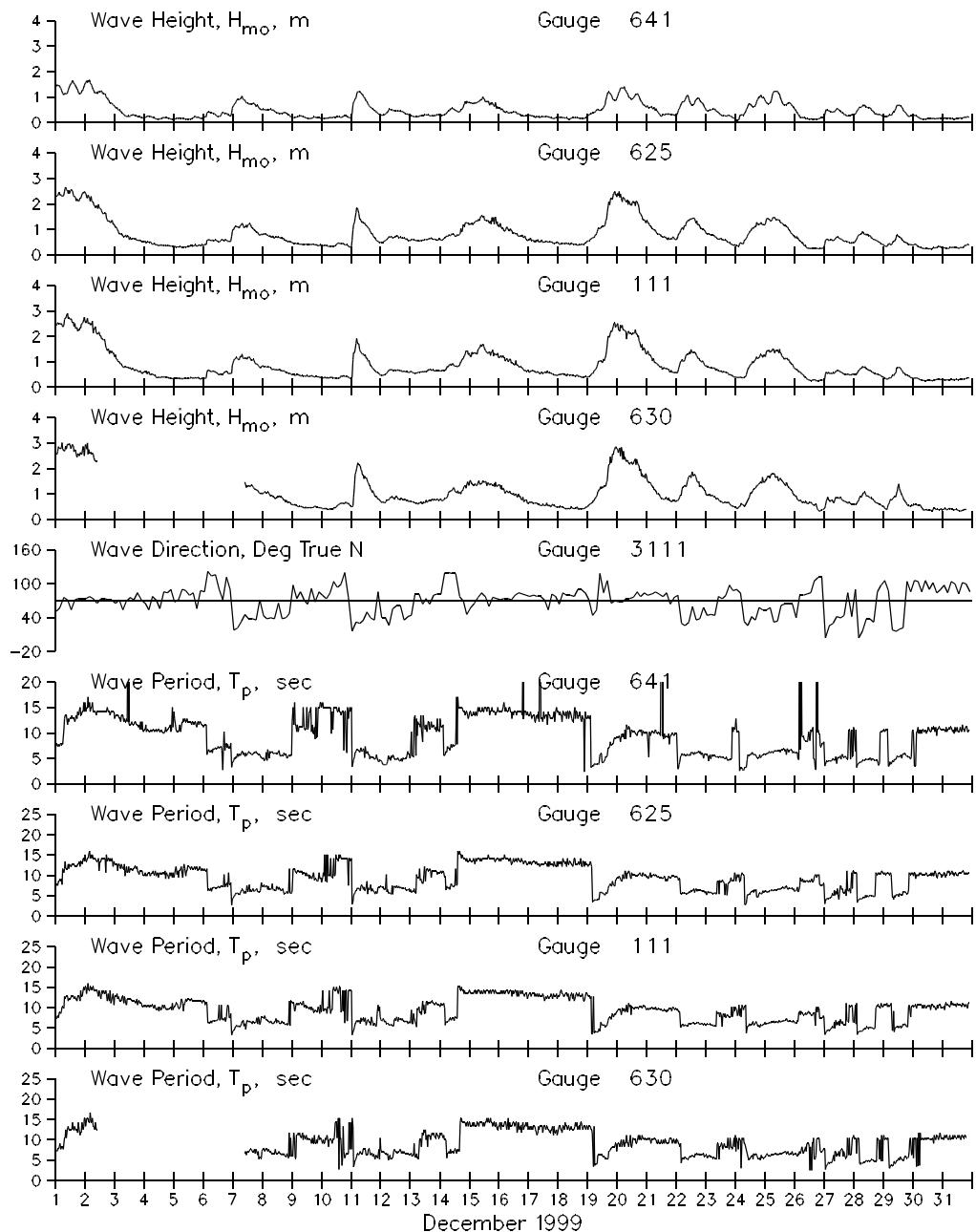


Figure 5. Wave Heights and Periods

4 Current Data

Current data (Table 5) are collected from a Sontek acoustic current meter and by visually observing the movement of small drogues on the water surface in the surf and at the seaward end of the pier, as well as 500 m updrift of the pier, approximately 12 m offshore (Table 6).

Since the shoreline orientation is approximately N20W, longshore currents flow either toward 340 deg (i.e. northward) or toward 160 deg (i.e. southward). Similarly, cross-shore currents are either onshore (westward) or offshore (eastward). All current speeds are given in centimeters per second (cm/sec). Resultant speeds and directions are determined by vector averaging the cross-shore and longshore data. Current directions indicate the direction that the current is moving towards. Current data are plotted in Figure 2.

Table 5
Current Meter Data - Gauge 3539

DECEMBER 1999											
		Cross	Long			Cross	Long			Cross	Long
Day	Time	Shore	Shore	Speed	Dir	Day	Time	Shore	Shore	Speed	Dir
1	100			1300		22	100			100	
	700			1900			700			700	
	1300	Data		12	100		1300			1300	
	1900				700		1900			1900	
2	100	available		1300		23	100			700	
	700			1900			700			700	
	1300	at a		13	100		1300			1300	
	1900				700		1900			1900	
3	100	later		1300		24	100			700	
	700			1900			700			700	
	1300	date.		14	100		1300			1300	
	1900				700		1900			1900	
4	100			1300		25	100			700	
	700			1900			700			700	
	1300			15	100		1300			1300	
	1900				700		1900			1900	
5	100			1300		26	100			700	
	700			1900			700			700	
	1300			16	100		1300			1300	
	1900				700		1900			1900	
6	100			1300		27	100			700	
	700			1900			700			700	
	1300			17	100		1300			1300	
	1900				700		1900			1900	
7	100			1300		28	100			700	
	700			1900			700			700	
	1300			18	100		1300			1300	
	1900				700		1900			1900	
8	100			1300		29	100			700	
	700			1900			700			700	
	1300			19	100		1300			1300	
	1900				700		1900			1900	
9	100			1300		30	100			700	
	700			1900			700			700	
	1300			20	100		1300			1300	
	1900				700		1900			1900	
10	100			1300		31	100			700	
	700			1900			700			700	
	1300			21	100		1300			1300	
	1900				700		1900			1900	
11	100			1300			1900			1900	
	700			1900							

KEY:

+cross-shore = offshore, cm/sec
 -cross-shore = onshore, cm/sec
 +longshore = south, cm/sec
 -longshore = north, cm/sec
 Speed = Resultant speed, cm/sec
 Dir = Resultant direction, degrees true north

Table 6
Visually Observed Current Data

Dec 1999											
Day	Pier End				Mid-Surf Zone				Beach		
	Cross Shore	Long Shore	Speed	Dir	Cross Shore	Long Shore	Speed	Dir	Location	Speed	Dir
1	0	152	152	160	no observation				North	49	S
2	9	30	32	143	no observation				North	22	S
3	9	30	32	143	24	-20	31	30	North	18	N
4	46	-38	60	30	3	-29	29	346	South	18	N
5	15	-16	22	22	-2	-30	31	337	South	9	N
6	11	-44	45	354	20	-68	71	357	South	8	N
7	7	47	47	151	8	51	51	151	North	35	S
8	5	15	16	143	10	18	20	131	North	12	S
9	7	18	19	138	5	-13	14	2	North	6	S
10	0	30	30	160	16	-36	39	4	South	6	N
11	13	51	52	146	39	32	50	110	North	43	S
12	0	-36	36	340	5	30	31	151	North	18	S
13	0	-47	47	340	4	-27	27	349	South	16	S
14	-14	-68	69	329	-6	-32	33	329	South	12	N
15	-5	47	47	166	25	28	37	118	North	6	N
16	30	30	43	70	12	-61	62	351	North	30	N
17	0	0	0	0	17	-17	25	25	North	30	S
18	11	-10	15	26	16	-47	50	359	South	51	N
19	-13	9	16	214	2	-30	31	343	South	61	N
20	-2	36	36	163	0	0	0	no observation			
21	0	41	41	160	18	-24	30	17	South	51	N
22	30	122	126	146	0	122	122	160	North	67	S
23	4	28	28	151	-7	23	24	177	North	24	S
24	-12	29	31	182	-11	28	30	182	North	21	S
25	-11	76	77	169	0	122	122	160	North	74	S
26	33	-44	54	17	28	-47	55	11	South	3	N
27	6	13	14	133	9	29	30	143	South	12	S
28	1	14	14	157	0	32	32	160	South	30	S
29	8	28	29	143	1	22	22	157	North	23	S
30	13	-27	30	7	7	-15	16	4	South	30	N
31	13	12	18	70	0	-23	23	340	South	51	N

KEY:

+cross-shore = offshore, cm/sec
 -cross-shore = onshore, cm/sec
 +longshore = south, cm/sec
 -longshore = north, cm/sec
 Speed = Resultant speed, cm/sec
 Dir = Resultant direction, degrees true north

5 Visual Observations

Visual wave direction measurements (Table 7) of both the primary wave train (i.e. that having the higher wave heights) and the secondary wave train (which must be clearly distinguishable as a wave train separate from the primary waves but not surface chop or capillary waves) are taken daily at the seaward end of the pier. The pier axis (considered perpendicular to the beach at the FRF) is oriented 70 deg east of true north; consequently, wave angles greater than 70 deg indicate that the waves were coming from the south side of the pier.

The width of the surf zone (seawardmost breaker position to shoreline) is determined from the pier deck.

Measurements of surface water temperature, density, and depth of visibility are also taken daily at the seaward end of the pier. A Bucket Thermometer is lowered about 0.3 m into the water and allowed to remain for at least one minute. The temperature is then read, and a hydrometer is used to determine the density. A Secchi disc is used to determine the depth of visibility.

Table 7
Visual Observations

Dec 1999								
Day	Time	Wave Approach Angle at Pier End (degrees from True N)			Water Characteristics at Pier End			
		Primary	Secondary	Surf Zone	Width, m	Temp., C	Density g/cc	Secchi Vis., m
1	0758	60	10		441	9.4	1.0220	0.3
2	0824	65	55		364	11.1	1.0206	0.3
3	0803	60	55		122	12.0	1.0218	0.3
4	0902	80			79	12.8	1.0239	0.3
5	0845	80			4	13.0	1.0242	0.3
6	0828	95	979		10	13.7	1.0244	1.5
7	0830	40	350		119	13.4	1.0247	0.6
8	0837	50	60		77	12.6	1.0248	1.2
9	0812	85	70		12	11.8	1.0241	1.5
10	0706	95	80		10	12.4	1.0245	1.8
11	1219	45	55		153	12.5	1.0246	0.6
12	1323	55	85		110	13.1	1.0240	2.4
13	0809	75	70		98	13.1	1.0242	2.1
14	0751	90	150		158	13.3	1.0241	1.8
15	0810	75	45		165	12.2	1.0241	2.4
16	0900	55			102	12.3	1.0243	0.3
17	0740	85			107	11.7	1.0242	0.6
18	0800	100	50		87	12.1	1.0243	1.8
19	0740	40	90		101	12.3	1.0243	2.1
20	0740	60	80		357	10.8	1.0218	2.1
21	0810	100	50		76	11.2	1.0273	2.4
22	0718	25			93	10.9	1.0206	0.3
23	0705	60	30		11	10.1	1.0208	1.8
24	0800	25			8	10.5	1.0220	1.5
25	0955	30			130	8.8	1.0218	0.3
26	0905	none visible			2	10.5	1.0230	0.3
27	0715	60	20		13	10.5	1.0239	2.1
28	0746	30			82	9.6	1.0238	1.5
29	0750	20	90		76	9.8	1.0245	1.2
30	0815	90			85	8.7	1.0240	1.5
31	0910	100	140		66	10.7	1.0248	2.4

6 Water Levels

Since 1978, the National Oceanic and Atmospheric Administration (NOAA)/National Ocean Service (NOS) has operated a primary tide station (No. 865-1370) at the seaward end of the FRF pier. A NOS acoustic tide gauge (Next Generation Water Level Measurement System, NGWLMS) is used to collect water level data every 6 minutes throughout the month.

The variation in water level during the month is shown in Figure 6 along with a list of means and extreme values. This presentation is useful in identifying effects of both meteorological and astronomical forces on the open coast water level. Table 8 contains the range, high, low, and mean water level for each 12.42-hr tidal cycle.

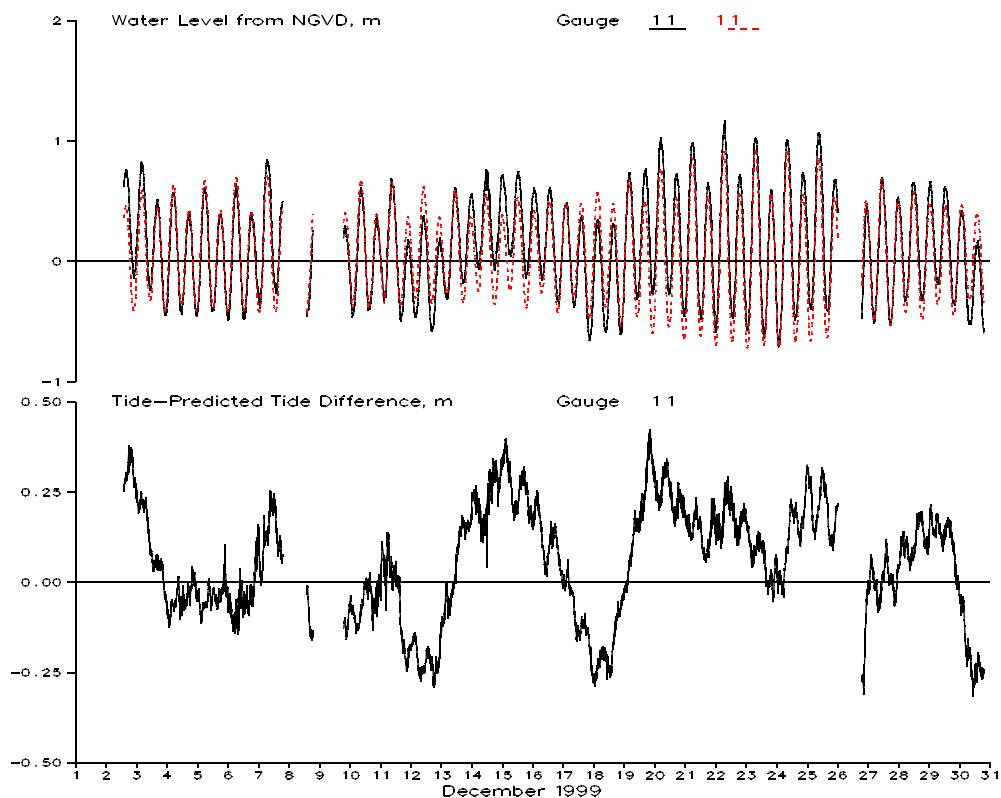


Figure 6. Water Level Variation

Table 8
Water Levels, m NGVD

DEC 1999 Tide Levels															
High			Low			Mean	Range	High			Low			Mean	Range
Day	Time	m	Day	Time	m	m	m	Day	Time	m	Day	Time	m	m	
1	218	0	2354	No data this cycle		16	0.62	15	1848	-0.14	0.25	0.76			
1	1424		1	818	No data this cycle	16	0.62	16	0718	-0.16	0.22	0.78			
2	318	1	2054	No data this cycle		17	0.49	16	2012	-0.35	0.09	0.84			
2	1530	2	924	No data this cycle		17	0.38	17	0824	-0.39	-0.02	0.77			
3	0342	0.83	2	2148	-0.14	0.34	0.97	18	0306	0.35	17	2030	-0.66	-0.15	1.02
3	1618	0.52	3	1030	-0.25	0.14	0.77	18	1454	0.32	18	0906	-0.59	-0.14	0.91
4	0454	0.57	3	2236	-0.46	0.06	1.03	19	0406	0.74	18	2106	-0.61	0.07	1.35
4	1700	0.41	4	1112	-0.44	0.01	0.86	19	1648	0.77	19	1000	-0.32	0.24	1.10
5	0536	0.61	4	2324	-0.46	0.07	1.07	20	0442	1.03	19	2212	-0.28	0.38	1.31
5	1730	0.40	5	1130	-0.42	-0.01	0.82	20	1718	0.73	20	1112	-0.28	0.23	1.01
6	0618	0.65	6	0012	-0.49	0.07	1.14	21	0542	0.99	20	2324	-0.46	0.28	1.45
6	1806	0.41	6	1212	-0.48	-0.02	0.89	21	1736	0.66	21	1206	-0.49	0.08	1.15
7	0654	0.85	7	0042	-0.39	0.25	1.24	22	0654	1.17	21	2354	-0.59	0.29	1.76
7	1906		7	1312	No data this cycle			22	1918	0.73	22	1312	-0.48	0.13	1.21
8	718	8	54	No data this cycle		23	0706	1.02	23	0054	-0.58		0.23	1.60	
8	1936	8	1342	No data this cycle		23	1942	0.60	23	1400	-0.64		-0.03	1.24	
9	748	9	130	No data this cycle		24	0754	1.01	24	0154	-0.71		0.16	1.73	
9	2012	9	1418	No data this cycle		24	2036	0.74	24	1436	-0.50		0.13	1.24	
10	0842	0.61	10	0154	-0.47	0.06	1.08	25	0906	1.07	25	0254	-0.40	0.33	1.47
10	2118	0.38	10	1424	-0.41	-0.03	0.80	25	2136	0.69	25	1630	-0.42	0.13	1.11
11	906		11	236	No data this cycle			26	954		26	330	No data this cycle		
11	2200	0.18	11	1548	-0.50	-0.14	0.68	26	2224		26	1630	No data this cycle		
12	0954	0.38	12	0324	-0.47	-0.06	0.85	27	1100	0.70	27	0448	-0.51	0.09	1.22
12	2254	0.20	12	1630	-0.58	-0.19	0.78	27	2324	0.54	27	1724	-0.54	0.01	1.07
13	1036	0.62	13	0424	-0.32	0.14	0.94	28	1136	0.66	28	0518	-0.33	0.17	0.99
13	2348	0.56	13	1642	-0.19	0.19	0.75	29	0112	0.66	28	1818	-0.33	0.15	0.99
14	1112	0.77	14	0530	-0.07	0.34	0.84	29	1212	0.62	29	0648	-0.19	0.21	0.81
15	0006	0.72	14	1748	-0.08	0.33	0.80	30	0142	0.42	29	2012	-0.37	0.02	0.79
15	1236	0.75	15	0618	0.04	0.39	0.71	30	1424	0.18	30	0848	-0.53	-0.19	0.71

7 Bathymetry

A. Nearshore Profiles. In order to document profile response away from the pier, surveys of four profile lines extending 900 to 1,000 m from shore and located 489 and 581 m north and 517 and 608 m south of the FRF pier are conducted bi-weekly, after storms, and during more complete bathymetric surveys.

These profiles are obtained using a Trimble 4000 SSE GPS for positioning, in combination with the Coastal Research Amphibious Buggy (CRAB), a 10.7 m high, self-powered, mobile tripod on wheels.

Figure 7 shows the last survey in November and the survey(s) in December on profile line 188, located 517 m south of the pier.

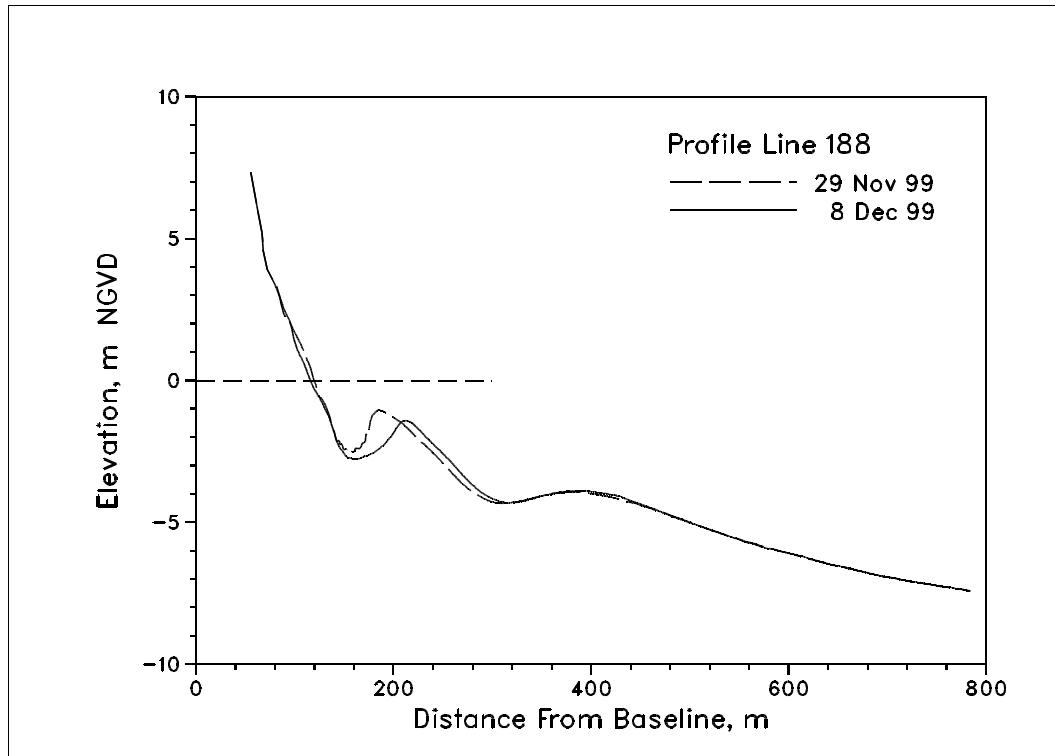


Figure 7. Monthly CRAB Profiles on Profile Line 188.

The profile envelope (Figure 8) reflects the maximum changes that occurred on the profile during 1999. Cross-hatched areas indicate changes to the annual envelope which occurred in December.

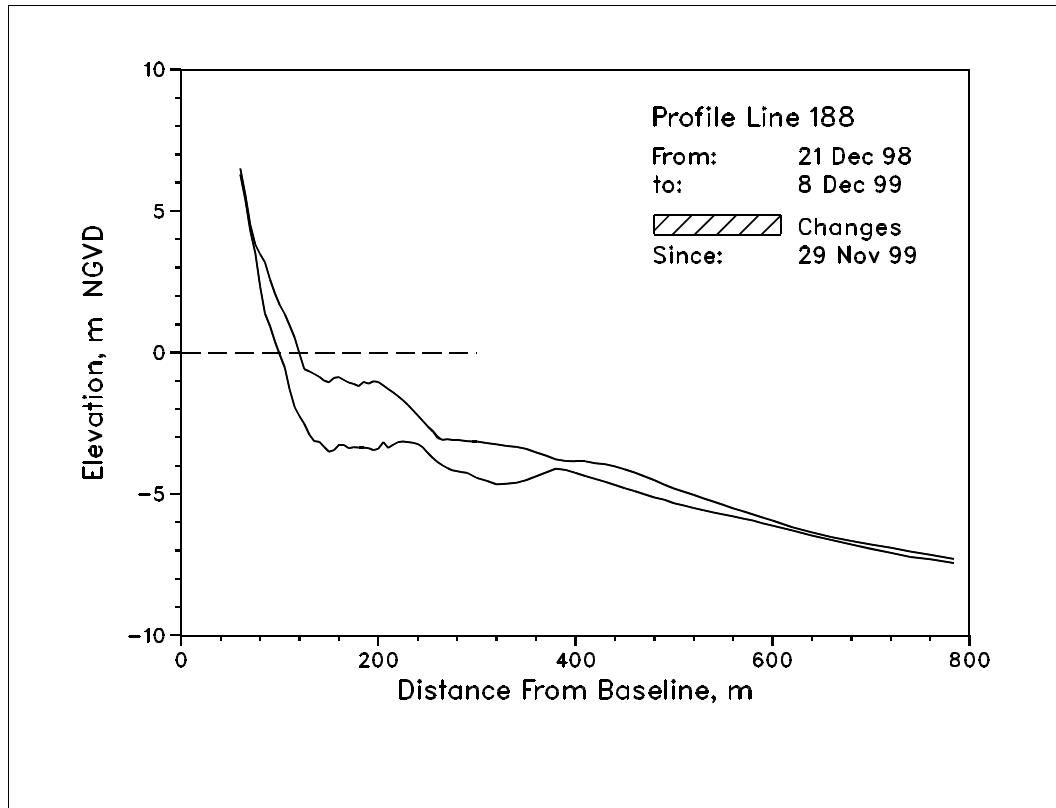


Figure 8. Profile Envelope - Profile Line 188.

B. Bathymetry. Figure 9 includes a two- and three-dimensional contour map and a change plot derived from the bathymetric survey on 9 December. Wide contour lines on the change diagram represent eroded areas; thin lines indicate deposition.

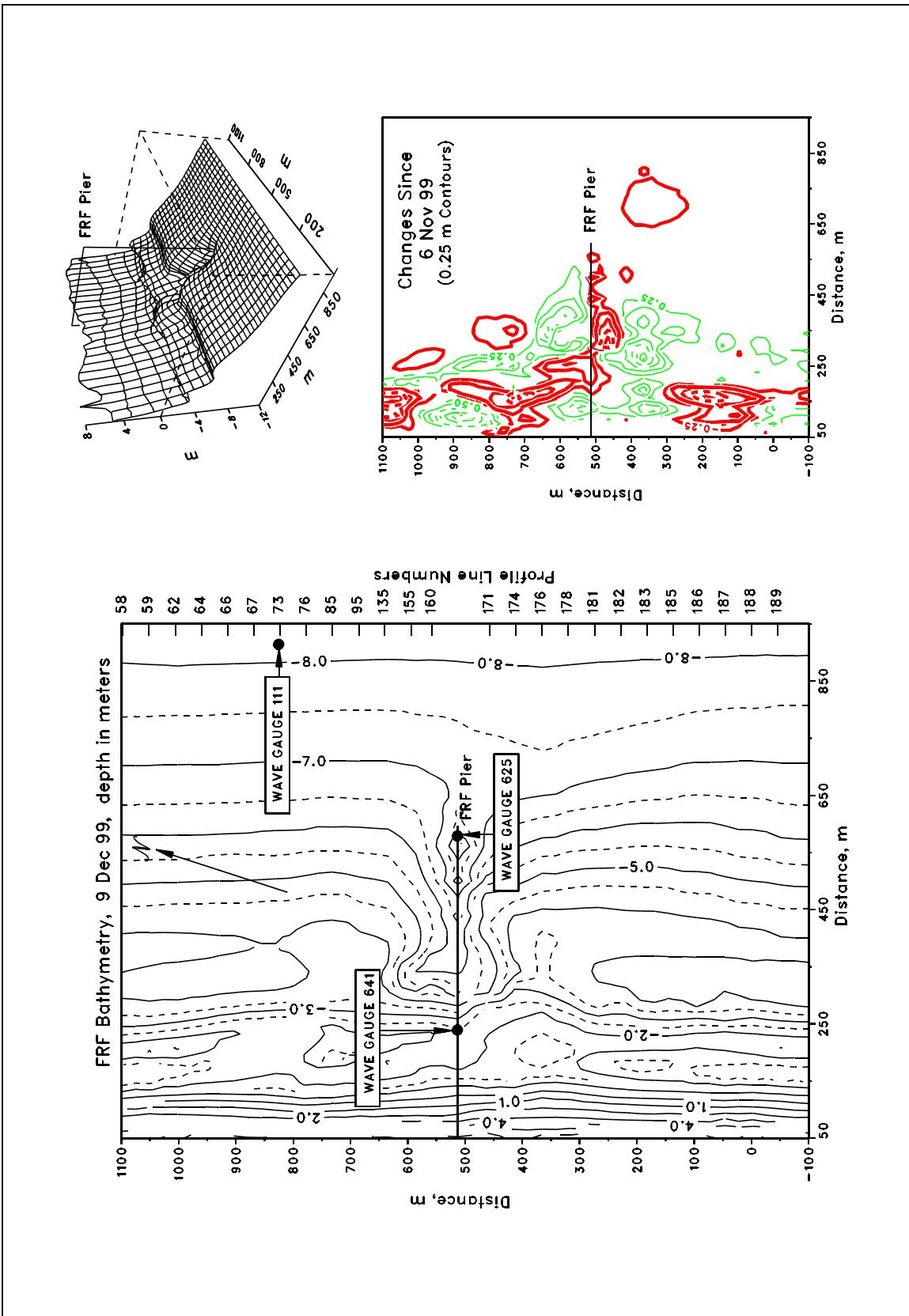


Figure 9. FRF Bathymetry, Depths Relative to NGVD

8 Special Events

A. Storm Data Collection. The following list identifies times when the wave height H_{mo} at the seaward end of the pier exceeded 2 m.

	<u>Start</u>	<u>End</u>
	30 Nov (1300)	02 Dec (0700)
	19 Dec (1708)	20 Dec (1600)

B. Storm Synopsis.

30Nov-02Dec Northwesterly winds associated with a high pressure system, to the west, continued to blow offshore at 16 m/s at 2342 EST on 30 November. The maximum H_{mo} , at gauge 625, reached 2.7 m ($T_p=11.6$ s) at 0842 EST on 01 December. There was no precipitation.

19Dec-20Dec Northeasterly winds were funneled between a New England high pressure system and a low pressure system over South Carolina . Maximum onshore winds (NE) reached 12 m/s at 2116 EST on 19 December. The maximum H_{mo} , at gauge 625, reached 2.5 m ($T_p=9.8$ s) at 0134 EST on 20 December. The minimum atmospheric pressure was 1014mb. There was no precipitation.